Transporting Flower Bulbs in an Experimental Ambient Air-Cooled Van Container

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PREFACE

This project is part of the broad program of the Agricultural Marketing Research Institute of the Northeastern Region, Agricultural Research, Science and Education Administration, U.S. Department of Agriculture, to improve the distribution of agricultural products for the benefit of farmers, consumers, and private industry.

The research was conducted in cooperation with private companies, including ocean carriers, shippers, marketing cooperatives, and container-leasing firms.

Special credit is due the following individuals for their cooperation and assistance: Th. Langeveld, Langeveld Bulb Company, Inc., Lisse, the Netherlands; F. X. C. Looyesteyn and G. H. van Nieuwenhuizen, Sprenger Instituut, Wageningen, the Netherlands; M. Geelhoed, Flower Bulb Transportation Bureau, Rotterdam, the Netherlands; H. A. Soder, United States Lines, New York, N.Y.; and S. Leggat, Container Transport International, Inc., White Plains, N.Y.

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TRANSPORTING FLOWER BULBS IN AN EXPERIMENTAL AMBIENT AIR-COOLED VAN CONTAINER

By William G. Kindya,[1] August De Hertogh,[2] and Anton Bongers[3]

ABSTRACT

To test the feasibility of shipping flower bulbs in an experimental dry-freight van container, a test shipment was made from the Netherlands to the United States. Bulb and air temperatures and relative humidity were recorded in transit in both the experimental van container and a conventional refrigerated van container used as a control. The experimental van container, which offered increased load capacity and reduced energy consumption, used outside air to cool and ventilate the flower bulbs.

Sample bulbs were grown in forcing experiments at Michigan State University to determine if any differences existed between the bulbs transported in the two vans. No differences in the forcing characteristics of the tulip and hyacinth cultivars could be attributed to the shipping containers.

Design modifications are given for the experimental van container to incorporate its equipment into a compact portable unit for easy removal, maintenance, and storage.

KEYWORDS: Flower bulbs, van container, ambient air, ventilation, tulips.

INTRODUCTION

The shipping industry has expressed continuing interest in a convertible dry-freight van container specifically modified for ambient air cooling of agricultural products which require moderate temperatures during transportation.

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Such a modified van container, if used commercially, could result in increased payload capacity and reduced energy consumption in transit compared with a refrigerated van container.

This report describes a test shipment in which a commercial refrigerated van container is compared with an experimental container that used outside air to cool and ventilate the product. The cargo was flower bulbs, shipped from the Netherlands to the United States during September 1976.

TEST OBJECTIVES

1. To determine the feasibility of shipping flower bulbs in a modified dry-freight van container equipped with forced-air ventilation and a heater.

2. To record, in transit, air and flower bulb temperatures and relative humidity inside the experimental van container and inside a conventional refrigerated van container.

3. To determine if any differences existed between plants forced from the bulbs transported in the two van containers.

4. To identify desirable modifications for the experimental van container based on results of the test shipment.

DESCRIPTION OF VAN CONTAINERS

The conventional refrigerated van container used as a control during this test was a standard 40-foot (12.19-m) model. Refrigerated air was discharged from a ceiling mounted canvas duct. This air passed through the cargo area and returned to the refrigeration coil through T-rail channels in the van container's floor. The ventilation doors on the refrigerated van container were kept open during transit to assure adequate air exchange.

The experimental van container was a 12.19-m aluminum dry-freight van container with a solid wood floor and 6.35-mm plywood lining the inside surface of the side walls and ceiling. This experimental van container was modified by installing a cargo retaining wall, an air blower, heater, louvers, and electrical controls on the inside front wall as described in an earlier report.4/ The air intake and exhaust were located in the front end of the van container. These locations were chosen primarily because of structural limitations and operating convenience. Other configurations should be considered and tested for specific carrier applications.

4/ Kindya, William G. Modifications in ambient air-cooled van container for transporting agricultural products to overseas markets. U.S. Dept. Agr., Agr. Res. Serv., ARS-NE-83, June 1977.

TRANSIT TEST PROCEDURES

The two van containers were loaded with flower bulbs during the first week of September 1976. They were held at port in the Netherlands for 2 days, then transported by a commercial containership to New Jersey. The ship left Rotterdam on September 9 and arrived in New Jersey on September 19. The van containers were unloaded on September 20. Elapsed time from loading until unloading the bulbs was 13 days.

Stacking Patterns

In the conventional refrigerated van container, the cartons of flower bulbs were stacked in a commercially used pattern (fig. 1). The cartons were tight-stacked lengthwise, leaving alternate 75- to 100-mm air spaces on one side of each layer. By loading alternately in this manner, no lengthwise channels were formed.

The experimental van container was loaded with a pigeonhole loading pattern (fig. 2). Each alternating layer (layers 1, 3, and 5) had seven cartons across; six cartons were spaced equally in the second and fourth layers. This pattern provided air channels of approximately 50 to 75 mm between cartons lengthwise through the van container. A header stack, consisting of six cartons, was placed across the front bulkhead (fig. 3). A similar stack was placed at the rear of the load to avoid blocking the air channels (fig. 4).

Figure 1.--Cartons of flower bulbs depicting loading pattern used in conventional refrigerated van container.

Figure 2.--Cartons of flower bulbs depicting loading pattern used in experimental ambient air-cooled van container.

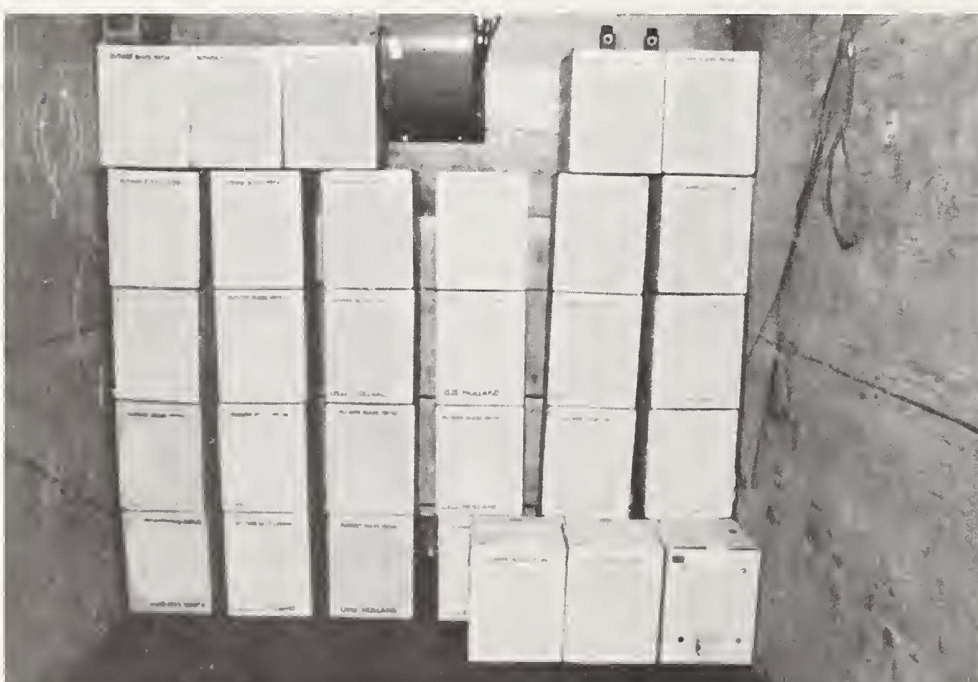

Figure 3.--Front header stack of cartons in experimental van container. Air was admitted into cargo compartment through an opening at bottom of front bulkhead.

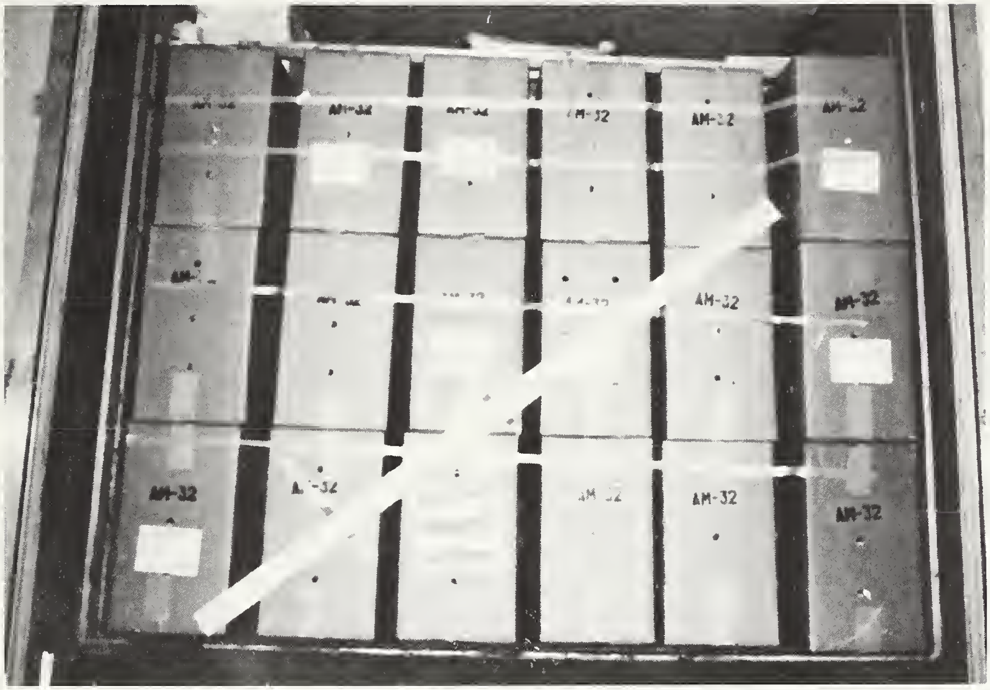

Figure 4.--Rear stack of cartons in experimental van container. Note the load bracing.

A total of 872 cartons was loaded in the conventional refrigerated van container; 1,224 cartons were loaded in the experimental van container. The larger number of cartons was possible in the experimental van container because it had no refrigeration unit occupying about 90 cm of the front end, no insulation in the walls, floor, and ceiling, and no T-bar flooring. This added capacity, if used, would lower the transportation cost per load.

Precautions Against Ethylene Gas Buildup

Flower bulbs transported in an enclosed environment require adequate air circulation and exchange to prevent ethylene gas buildup. The major source of ethylene gas is fusarium-infected bulbs which are sometimes present in shipments of healthy bulbs. If allowed to exceed tolerable limits during transport, it can cause abortion of the embryonic flower.

The experimental ambient air-cooled van container used in this test provided a fresh air exchange rate of about 1560 cubic meters per hour. The conventional refrigerated van container was modified to provide outside air for ventilation.

No ethylene buildup was detected in either van container during a 2-day period before it was loaded aboard the containership for transport to the United States. No air samples were taken during the voyage or at destination.

Temperatures and Relative Humidity in Transit

During transit, flower bulb and air temperatures inside the two van containers were measured at 1-hour intervals; the readings were recorded on self-contained magnetic tape cassettes. Flower bulb pulp temperatures were measured by a thermistor temperature sensor inserted into bulbs inside sample cartons. Air temperatures were measured in the spaces between the cartons.

The thermostat of the conventional refrigerated van container was set at 19 °C. Average flower bulb temperatures in the refrigerated van container decreased from 25 to 22 °C in approximately 60 hours (fig. 5). Thereafter, they were maintained at 20 to 22 °C. The average temperature in the air channels fluctuated from 17 to 25 °C during the first 30 hours and thereafter was maintained around 21 °C.

The temperatures of the flower bulbs in the experimental van container decreased from 26 to 22.5 °C within the first 30 hours. After 4 days, the temperature increased gradually to 26 °C on the last day. The average flower bulb temperature in the experimental van container followed the outside air temperature but lagged behind and did not reach the peak highs and lows.

The relative humidity inside the two van containers was measured in transit by hygrothermographs placed in the cargo areas. At the beginning of the voyage, the relative humidity inside both van containers was 65 percent. The relative humidity during transit is illustrated in figure 6.

FORCING EXPERIMENTS

In Rotterdam, test packages of flower bulbs containing samples of tulip and hyacinth cultivars were selected from the same lots and placed in the center of each van container in the top layer of the load. These samples, on arrival in New Jersey, were sent to Michigan State University by air freight. There they were forced, using rooting-room and greenhouse conditions, to determine if any differences existed between the flower bulbs transported in the two van containers.

The tulip cultivars were: 'K&M's Triumph,' 'Olaf,' and 'Paul Richter.' The hyacinths consisted of a Mixed group (a mixture of three cultivars) and the cultivar 'Pink Pearl.'

On September 23, the bulbs were received at Michigan State University. Shoot development was recorded (table 1), and the bulbs were placed in dry storage at 13 °C. The tulips were planted in the greenhouse on September 27. Temperatures were maintained at 9 °C until November 5, 5 °C until January 7, and 2 °C for the remainder of the forcing period. The hyacinths were planted on October 18. Temperatures were maintained at 9 °C for the remainder of the forcing period.

The forcing experiments used three replications per treatment. Results of the forcing tests are given in tables 2 and 3.

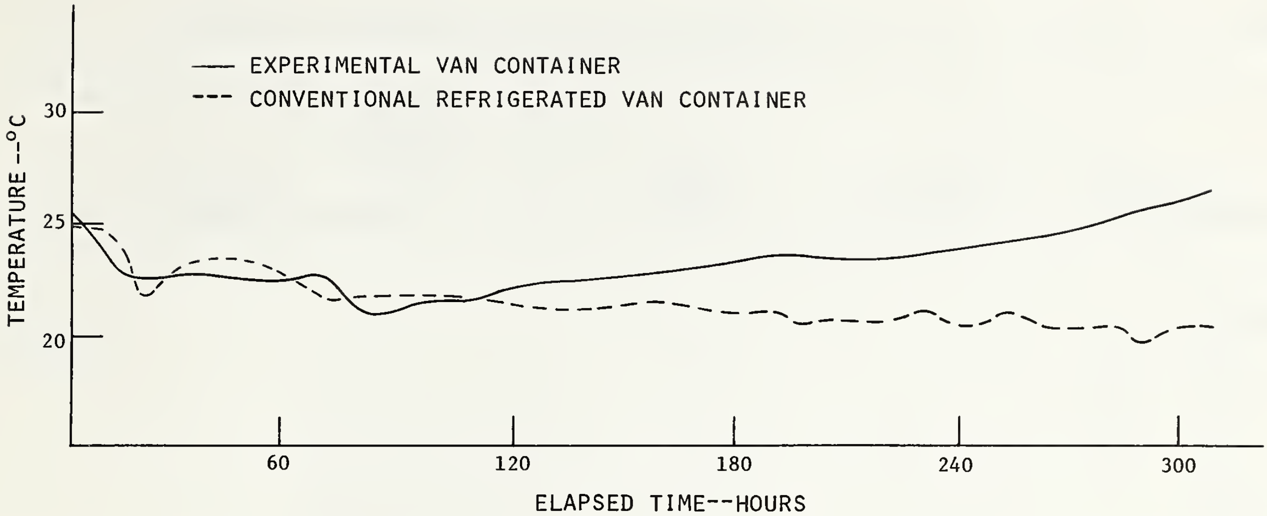

Figure 5.--Average flower bulb temperatures during transit from the Netherlands to New Jersey.

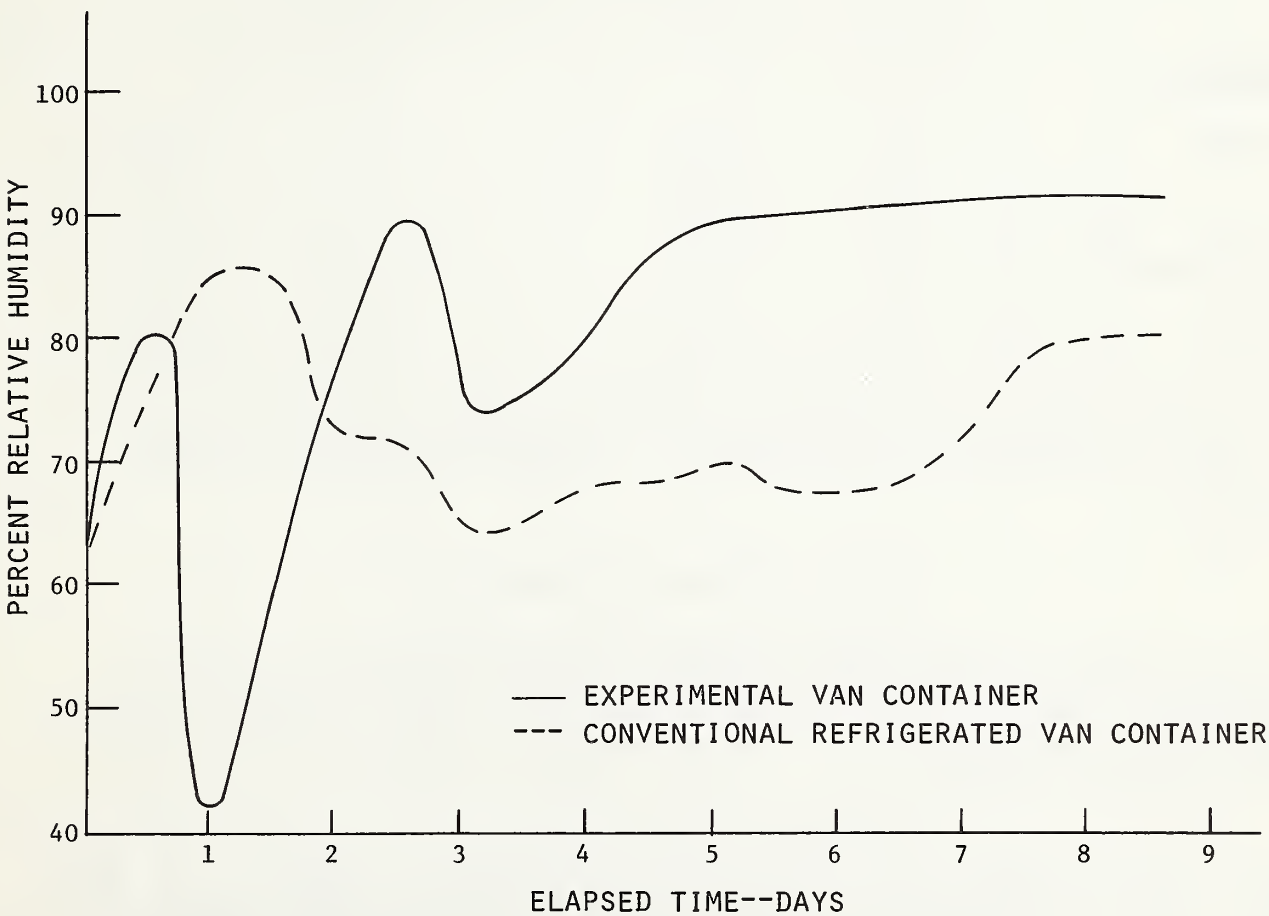

Figure 6.--Relative humidity inside containers during transit from the Netherlands to New Jersey.

Table 1.--Length of bulb shoots on arrival at Michigan State University, September 23, 1976

Cultivar 1/	Type of container 2/	Length (mm)			
		Total shoot	Tepals	Stamens	Inflorescences
Tulips					
K&M's Triumph	1	20.0	6.1	9.3	--
	2	24.2	7.8	11.8	--
Olaf	1	17.3	6.9	7.6	--
	2	18.3	5.7	7.9	--
Paul Richter	1	15.8	5.1	6.3	--
	2	20.9	8.2	8.1	--
Hyacinths					
Mixed	1	23.7	--	--	14.2
	2	23.4	--	--	14.9
Pink Pearl	1	20.8	--	--	13.9
	2	23.8	--	--	14.8

1/ The leaves of all bulbs were in closed (normal) condition on arrival.
2/ 1 = experimental van container, 2 = conventional refrigerated van container.

RESULTS OF FORCING EXPERIMENTS

1. On arrival at Michigan State University, sample tulips from the experimental van container had less shoot development than samples from the conventional refrigerated van container (table 1). Further testing, especially during warmer months, is needed to sustantiate this finding and to determine the extent of its impact.

2. There were no differences in the forcing characteristics of the three tulip cultivars that could be attributed to the shipping containers. The high percentages of flower abortion for treatments C1 and C2 of K&M's Triumph were due to large fluctuations in greenhouse conditions which occurred shortly before anthesis.

Table 2.--Tulip flowering data

Cultivar	Treatment and container 1/	Average date of flowering	Average days to flowering	Percent of plants flowering	Length (cm)			
					Flower	Total plant	Internode First	Internode Last
K&M's Triumph	A 1	Feb. 3	31	98	5.0	40.3	7.4	9.5
	2	Feb. 3	31	98	4.9	35.8	6.5	8.5
	B 1	Feb. 11	25	100	4.8	37.9	8.3	8.8
	2	Feb. 11	25	92	4.7	34.9	7.1	8.2
	C 1	Feb. 20	20	70	4.5	30.9	6.5	7.3
	2	Feb. 21	21	81	4.4	31.9	7.7	6.6
	D 1	Mar. 7	21	90	4.7	40.7	7.0	11.7
	2	Mar. 9	23	90	4.8	41.3	6.9	11.0
Olaf	A 1	Feb. 5	33	100	4.8	31.8	8.1	6.7
	2	Feb. 3	31	100	4.9	31.0	8.5	5.7
	B 1	Feb. 12	26	98	4.6	32.6	9.5	6.5
	2	Feb. 11	25	100	4.8	32.8	10.2	5.7
	C 1	Feb. 22	22	98	4.4	29.9	8.9	4.9
	2	Feb. 20	20	98	4.6	31.2	9.9	4.9
	D 1	Mar. 9	23	98	4.5	32.2	9.1	5.9
	2	Mar. 7	21	98	4.6	31.3	9.7	5.5
Paul Richter	A 1	Jan. 30	27	98	4.5	33.5	6.4	8.3
	2	Feb. 1	29	96	4.6	34.6	6.6	9.4
	B 1	Feb. 9	23	98	4.4	34.2	6.5	8.9
	2	Feb. 10	24	98	4.5	36.3	6.9	9.7
	C 1	Feb. 21	21	100	4.3	34.2	6.6	9.0
	2	Feb. 21	21	100	4.4	34.7	6.6	9.5
	D 1	Mar. 8	22	100	4.6	39.2	6.9	11.3
	2	Mar. 8	22	100	4.7	39.1	6.9	11.6

1/ A = 14 cold weeks beginning Jan. 3, B = 16 cold weeks beginning Jan. 17, C = 18 cold weeks beginning Jan. 31, D = 20 cold weeks beginning Feb. 14. 1 = experimental van container, 2 = conventional van container.

Table 3.--Hyacinth flowering data

Cultivar	Treatment and container 1/	Average date of flowering	Average days to flowering	Percent of plants flowering	Length (cm) Flower	Length (cm) Total plant
Mixed	A 1	Jan. 29	26	100	14.1	30.3
	2	Jan. 26	23	100	13.0	28.4
	B 1	Feb. 4	18	100	13.4	30.3
	2	Feb. 3	17	100	13.2	30.0
	C 1	Feb. 15	15	100	12.9	28.5
	2	Feb. 15	15	100	12.8	27.7
	D 1	Feb. 28	14	100	12.4	28.2
	2	Feb. 27	13	100	12.6	27.3
Pink Pearl	A 1	Jan. 25	22	100	11.4	23.5
	2	Jan. 26	23	100	11.5	24.0
	B 1	Feb. 3	17	96	11.9	25.5
	2	Feb. 2	16	100	12.6	26.1
	C 1	Feb. 15	15	100	11.3	23.2
	2	Feb. 13	13	100	11.2	22.9
	D 1	Feb. 28	14	100	11.9	25.7
	2	Feb. 27	13	100	11.9	23.4

1/ A = 11 cold weeks beginning Jan. 3, B = 13 cold weeks beginning Jan. 17, C = 15 cold weeks beginning Jan. 31, D = 17 cold weeks beginning Feb. 14. 1 = experimental van container, 2 = conventional van container.

3. The Mixed hyacinth lot contained at least three cultivars, and the data provided are a composite of all the cultivars. Again, there were no significant differences in the flowering characteristics which could be attributed to the containers.

MODIFICATION OF THE EXPERIMENTAL VAN CONTAINER

As a result of this and earlier tests, the experimental dry-freight van container was modified to a more practical and commercially usable prototype. The air blower, heater, air ducting, and controls were modified into a compact

modular unit that could be installed from the outside front end of the experimental van container. The unit was designed to be removed for maintenance and for storage during nonuse periods (fig. 7).

By having the equipment in portable module form, it can be used as needed, when a van container is assigned a load suitable for ambient air cooling. This use-as-needed system would require a limited number of units and would allow high utilization of those units.

The components of the modular air handling unit were mounted on a 60-cm x 1-m x 19-mm sheet of marine plywood installed into an opening in the front outside wall of the van container (fig. 8). In this way, all components of the system were located in the space between the front outside wall of the van container and the inside cargo retaining wall. The cargo retaining wall provided a flat surface against which cargo was stacked during transit. No equipment protruded into the cargo space.

The air intake duct was mounted separately below the modular unit. The opening of this intake was fitted with an air-water separation baffle to let in fresh air and keep out seaspray and rainwater during transit. A modular unit built for commercial use would have to be specifically designed for use in a marine environment. All parts used in the system were standard off-the-shelf items.

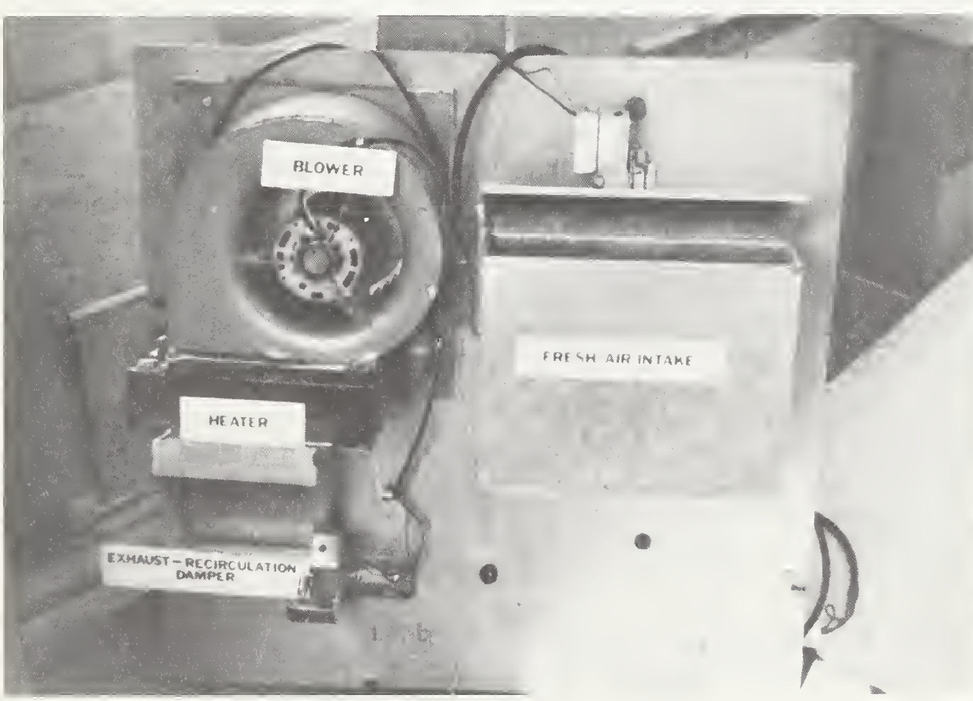

Figure 7.--Major components of air handling unit used to modify experimental dry-freight van container after test shipment of flower bulbs.

Figure 8.--Experimental ambient air-cooled van container (right) and conventional refrigerated van container (left) parked in container terminal yard prior to loading onto containership. Top opening in experimental van container is air outlet; bottom opening is air inlet.

Figure 9 illustrates the front section of a loaded van container with the forced air circulation system installed. The system functions in one of two operational modes: ventilating (using ambient air for cooling) and recirculating (heating, when necessary, to prevent product damage by chilling or freezing). The blower, operating continuously, either diverts air to the exhaust port for ventilation or sends it downward through the heating coils for recirculation. A two-stage thermostat controls operation of the air inlet, exhaust dampers, electric heater, and blower operation.

In the ventilating mode, the intake port is open and the exhaust-recirculation damper closes the recirculation duct. The exhaust port is open. Cool ambient air is pulled into the van container through the intake opening and is circulated through air channels in the load and through the boxes, where it picks up product heat. The warmed air is then expelled from the van container through the exhaust port.

In the recirculating mode, the intake port is closed. The exhaust-recirculation damper moves to the vertical position, closing the exhaust port and directing air from the blower through the recirculation duct opening. The heater is automatically turned on by the thermostat when the temperature of the circulating air falls below the thermostat setting. The incoming air is driven downward through the heater into the cargo space and is returned to the blower for recirculation.

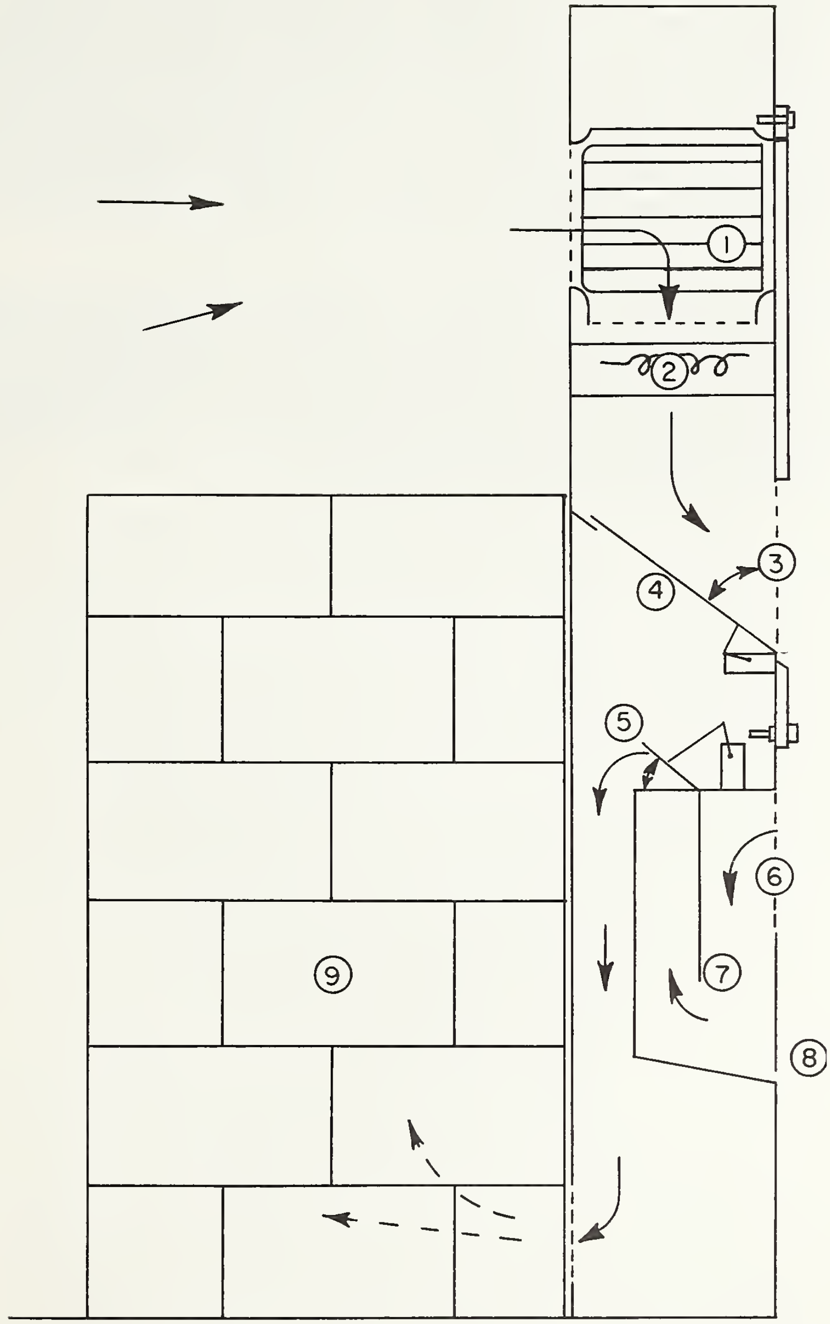

Figure 9.--Cutaway view depicting major components of ambient air-cooling system installed in front end of experimental van container: 1--Blower, 2--heater, 3--air outlet, 4--exhaust-recirculation damper, 5--hinged intake damper, 6--fresh air intake, 7--air-water separation baffle, 8--water drain, 9--agricultural products. Arrows indicate direction of airflow when system is in cooling mode.

CONCLUSIONS

While temperature and relative humidity were higher in the experimental van container throughout most of the voyage, forcing results indicated no significant differences between the flower bulbs transported in the two van containers. The experimental van container, with its increased load capacity and reduced energy consumption, appears satisfactory for certain shipping requirements. Specifically, the experimental van container seems advantageous for transporting dry-sale and late season forcing bulbs from Rotterdam to New Jersey during late September and cooler months. However, before these van containers are recommended for summer shipments of early forcing bulbs, more extensive testing should be conducted.

Future tests should use shipments made in August and early September and should include the more heat-sensitive cultivars. These are the Paul Richter, 'Gander,' 'Orient Express,' 'Most Miles,' and 'Golden Melody' tulips; and the Pink Pearl, 'Delft Blue,' and 'Ostara' hyacinths. In addition, weather conditions, ship routing, commodity handling procedures, growing conditions, and other factors should be explored.

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